

C.I.E.M.A.T.

INSTITUTE OF RADIOLOGICAL AND
ENVIRONMENTAL PROTECTION

RADIOLOGICAL MONITORING IN THE REGION OF PALOMARES
(REPORT OF THE FIRST SEMESTER OF 1990)

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(REPORT OF THE FIRST SEMESTER OF 1990)

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of the Report of the first
semester of 1990 of
"Radiological Monitoring in
Region of Palomares"

Madrid, 31 July 1990

Director of Institute

Signed

F. Vinger

Mr. D. Jose Luis Butragueno

Deputy Director General of Radiological Protection

Nuclear Safety Council

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RADIOLOGICAL MONITORING IN THE REGION OF PALOMARES
PERIOD: FIRST SEMESTER OF 1990

The radiological monitoring in the region of Palomares was implemented during the first semester of 1990, in accordance with the plan established in the report "RADIOLOGICAL MONITORING IN THE REGION OF PALOMARES: PROGRAM FOR 1990". The activities carried out are as follows:

1. MONITORING OF PERSONS

The activities corresponding to this section have been of two types:

a) Planning of the two campaigns of examinations for 1990 and partial implementation of the first.

b) Obtaining the results corresponding to the second campaign of examinations of 1989.

The following subsections reflect the content of each type of activity mentioned.

1.1. Examinations of 1990: Plans and Implementation

The planning for the examinations to be conducted in 1990 is subject to criteria and priorities described in the report "RADIOLOGICAL MONITORING IN THE REGION OF PALOMARES: PROGRAM FOR 1990", sent to the CSN in May 1990. According to the cited document, a list was established, consisting of 166 persons, for the purpose of being able to check 150 of them in two campaigns during the year, the first from June

¹Numbers in margin indicate foreign pagination. Commas in numbers indicate decimal points.

to September, and the second from September to December. for logistic reasons it cannot be estimated that all the 150 persons foreseen will be on the list consisting of 166 persons.

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To summarize, we may state that the list included the following groups and number of persons.

1-A) Persons who have given positive results of contamination in the urine on some occasion. It includes 25 persons.

1-B) Persons of Villaricos who asked to be checked because they were involved in tasks of decontamination at the time of the accident. It consists of 10 persons.

1-C) Persons who have reached the age of 12 and have not been checked. It includes 18 persons.

2-A) Persons who had shown a positive result at one time and subsequently negative results. Also persons who had been called for a check and had not come for some reason. It consists of 83 persons, of which 50 would be chosen.

2-B) Previously checked persons of Villaricos. Including 12 persons.

2-C) Persons less than 20 years old with only one check and negative results. It consists of 18 persons.

The rest of the people, up to a total of 150, will be persons accompanying the above.

This nominal list for 1990 sent to the municipal authority of Cuevas del Almazora (Almerio) is not considered closed, so as to be able to include at the end of the year, a few more persons who for certain reasons may be interested to check.

The first of these campaigns, which has already been conducted, includes altogether 60 persons distributed in the following priority groups:

Group 1-A:	11 persons
Group 1-C:	12 "
Group 2-A:	17 "
Group 2-C:	5 "
Accompanying persons:	15 "

The results of these analyses now being obtained, will be included in the report corresponding to the second semester of 1990.

1.2. Dosimetry of 1989 (Conclusion)

Of all 151 persons analyzed in 1989, the results of the analyses of urinary excretion of Pu-239 + Pu-240 and Am-241 in 72 of the persons who were checked in 1989 are given in the report of the second semester of 1989.

In the first semester of 1990, the analyses corresponding to the remaining 79 persons checked in 1989 were completed.

The results of the determinations conducted in the 79 persons indicated are as follows:

- Two persons gave results of Pu-239 + Pu-240 in urine higher than the AMD of the analytical method. The values of the concentrations of activity were 3.5 ± 0.5 mBq/24 hours urine and 0.9 ± 0.3 mBq/24 hours urine.

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The first corresponds to a 29 year old woman, whose result for Pu-239 + Pu-240 during a check in 1986 was less than the AMD of our method. Subsequent checks will have to be made, to complete the evaluation and to be definite about the existence of an internal contamination in this person, who will be called for a checkup in 1990 for this purpose.

The second corresponds to a 48 year old man who had previously shown a positive result which had led to an evaluation of the effective equivalent dose integrated in 50 years of 65.7 mSv. The value obtained in 1990 confirms his dose evaluation.

- The remaining 77 persons gave values of Pu-239 + Pu-240 less than the AMD of the analytical method (0.7 mBq/24 hours urine).

- The 79 persons checked gave values of Am-241 less than the AMD of the analytical method (0.7 mBq/24 hrs. urine).

Consequently, as a result of the annual summary corresponding to the results of the measurement of bio-elimination conducted on the 151 persons checked in 1989, we may indicate that in eight of these persons, positive values for plutonium in urine were found, and in three persons, positive values for Am-241.

Of the eight persons with results for Pu-239 + Pu-240 higher than the AMD, three of them had given previously positive results for Pu-239 + Pu-240, and their effective equivalent dose they would receive in 50 years was evaluated (see Report CIEMAT/PRYMA/M5A01/1/90 "RADIOLOGICAL MONITORING IN THE REGION OF PALOMARES, SECOND SEMESTER 1989).

The three persons who showed positive values of Am-241 had previously shown positive values of Pu-239, and the evaluation was made of the dose they would receive in 50 years by the incorporation of this radionuclide. (see Report CIEMAT/PRYMA/M5A01/1/90 "RADIOLOGICAL MONITORING IN THE REGION OF PALOMARES, SECOND SEMESTER 1989).

The dosimetric data derived from the results of bio-elimination, corresponding to the year 1989, confirm generally the conclusions put forward in the report CIEMAT/PRYMA/M5A01/1/90 "RADIOLOGICAL MONITORING IN THE REGION OF PALOMARES, SECOND SEMESTER 1989), already mentioned.

The direct determinations of pulmonary contamination by plutonium and americium by means of Pulmonary Radioactivity Counter, in the 19 persons checked for the first time in 1989, showed a contamination, while the measurements carried out did not give values higher than the detection limit of the equipment used.

1.2.1. Medical Monitoring

In the first stage of the Program of Radiological Monitoring in the Region of Palomares for 1990 (see Doc. M5A01/PI002/90) conducted during the period from 11-6-90 and 16-7-90, 60 persons underwent a medical check; they were divided as follows:

Group 1-A	11 persons	
Group 1-C	12	"
Group 2-A	17	"
Group 2-C	5	"
Not included in the lists	15	" (companions)

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In the medical check-ups conducted, according to the directives given by Safety Guide No. 7.4 "Bases for Medical Monitoring of Workers Exposed to Ionizing Radiations", and the recommendations of International Agencies, no pathology was determined at all which might be attributed to the incorporation of transuranic elements, coming from the residual contamination of the region.

We give below all the significant findings:

Absence of alterations	23
Slight alterations	22
Presence of pathologies	15
 1. TUMORS (140-239)*	
Uterine myoma	1
 2. DISEASES OF THE ENDOCRINE GLANDS, NUTRITION, METABOLISM AND IMMUNITY DISORDERS (240-279)	
Obesity	4
Hyperglycemia	6
Hypercholesterolemia	4
Mixed hyperlipoproteinemia	1
Diabetes mellitus type II	3
Diffuse normally functioning tumor of the mouth	1
*Code ICD-9th revision	
 3. DISEASES OF THE BLOOD AND THE HEMATOPOIETIC ORGANS (280-289)	
Ferropenic anemia	3
Monocytosis	1
 4. MENTAL DISORDERS (290-319)	
Depression syndrome	2
Anxiety neurosis	2

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Insomnia	2
Excess consumption of alcoholic beverages	1
5. DISEASES OF THE NERVOUS SYSTEM AND OF THE SENSORY ORGANS (320-389)	
Migraine	3
Presbycia	12
Hypermetropy	7
Myopia	2
Astigmatism	1
Pterygeum	1
Hypoacusia	1
Bilateral impacted cerumen	2
Peripheral vertigo	2
6. DISEASES OF THE CIRCULATORY SYSTEM (390-459)	
Varices of the lower limbs	2
First degree A-V blockage	2
Arterial hypertension	1
EEII venus insufficiency	1
7. DISEASES OF THE RESPIRATORY SYSTEM (460-519)	
Polynosis	1
Allergic rhinitis	1
Chronic asthmatic bronchitis	1
Chronic bronchitis	1
Intrinsic asthma	1
Respiratory insufficiency	1
Tonsil hypertrophy	1
8. DISEASES OF THE DIGESTIVE SYSTEM (520-579)	
Inguinal hernia	2
Biliary lithiasis	1
Lazy bladder syndrome	1

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Gastric dyspepsia	1
Aerophagya	1
Chronic constipation	1
Abdominal eventration	1
Hiatal hernia	1
Aphthae of the mouth	1

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9. DISEASES OF THE GENITOURINARY SYSTEM (580-629)

Urinary infection	4
Microscopic pyuria	6
Prostatic hypertrophy	1
Dysmennorhea	1
Ovarian Cyst	1

10. DISEASES OF THE SKIN AND THE SUBCUTANEOUS CELLULAR TISSUE (680-709)

Contact eczema	1
Acne	2
Vitiligo	1
Hyperhidrosis	1
Labial leucoplasia	1
Pedunculated verruga	1

11. DISEASES OF THE OSTEOMUSCULAR SYSTEM AND CONJUNCTIVE TISSUE (717-739)

Arthrosis of the knees	1
Cervical spondyloarthrosis	1
Constitutional scoliosis	2
Dorsalgia	1
Lumbago	1
Lumbosciatica	1
Asymmetry of the lower limbs	2

12. POORLY DEFINED SIGNS, SYMPTOMS AND MORBID CONDITIONS
(780-799)

ECG--AI hypertrophy	3
ECG--VI hypertrophy	1
ECG--Sinusoidal bradycardia	3
ECG--Sinusoidal tachycardia	1
ECG--Sinusoidal arrhythmia	3
ECG--Incomplete branch blocking	5
ECG--First degree A-V blocking	2
Spirometry--Decrease in values	4
Dyspnea	2
Elevation of the gamma-GT	1
Elevation of the VSG	2
Anorexia	1

13. TRAUMATISM AND POISONINGS (800-999)

Calcaneus fracture	1
Fracture of the phalanx of the hand	1

The findings gathered correspond to the pathology encountered every day in the periodical preventive check-ups of workers, whether or not they are exposed to ionizing radiations, and in our judgement there is nothing which would allow us to suspect a morbidity induced specifically by radioactive agents.

2. MONITORING OF THE ENVIRONMENT

2.1. Soils

In connection with the tracking of the contamination of the soil, the activities implemented during this semester are those specified below:

2.1.1. Samplings

a) Samples have been taken of the superficial layer of the soil, the first five centimeters, in 15 equidistant points at 25 m, located along the lot 2-0 and 2-1, to determine the superficial concentrations of Pu-239 + Pu-240 and Am-241 after the remodeling operations undergone by the zone.

b) 25 superficial samples were taken at 25 points located outside the zero line of contamination, at a kilometer distance around it, to obtain experimentally information of the range of resuspension.

2.1.2. Analyses

The routine operations of the analytical process for Pu and Am are continuing currently, although no additional results are available than those sent in the previous reports. The next semestral report will provide the estimates for 1990.

2.2. Air

The activities carried out during this first semester of 1990 were as follows:

2.2.1. Sampling

The continuous weekly samples of air in the three stations which operate continuously have been taken in the manner established in the report M5A01/PI002/90

"RADIOLOGICAL MONITORING IN THE REGION OF PALOMARES, PROGRAM

FOR THE YEAR 1990", sent to that CSN. These three stations correspond to references 2-1, 2-2 and P (urban zone).

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We collected 68 samples, with a volume of air of approximately 10,000 m³ per sample.

2.2.2. Plutonium Concentration

The radiochemical analyses to determine the concentration of Pu-239 + Pu-240 in samples of air taken weekly for the period 1983-1987 were implemented monthly and bimonthly to have as soon as possible average concentrations of Pu-239 + Pu-240 and Am-241 in air in the period 1983-1987.

Station P

The samples analyzed are distributed in the following manner, by collection dates:

P Station (urban zone):	40 samples of 1985
P Station (urban zone):	17 samples of 1986

The samples of 1985 correspond to those taken in the P Station during the period from January 5 to December 28, and are supplementary to those presented in the report M2A/PIO08/-/86, "RADIOLOGICAL MONITORING IN THE REGION OF PALOMARES (SECOND SEMESTER 1986)".

The values of the concentrations of Pu-239 + Pu-240 during 1985, in the P station (urban zone) are given in Table 1. As may easily be observed, this table includes the results already presented in the report of the second semester of 1986, to give a general view of the whole year.

On the basis of the whole of the values given in this Table 1, it is deduced that:

- The average value of the plutonium concentration in the urban region of Palomares, during 1985 was:

Station P (urban zone): $5.0 \mu\text{Bq/m}^3$.

- The category of plutonium concentrations in this urban zone, during 1985, was: Station P (urban zone): between 0.74 and $14.0 \mu\text{Bq/m}^3$.

- Both the average and maximum value of the concentration of plutonium during 1985 were very much below the concentration derived in the air ($5900 \mu\text{Bq/m}^3$) for plutonium compounds of Y class, according to what may be derived from the value established in the Spanish legislation (3) for the limit of annual incorporation by inhalation.

Table 2 gives the data corresponding to the station P in 1986. These samples cover the period from January to December 1986. Just as in Table 1, this table contains data previously presented in report M2A/PI008/-/86 to provide an overall view of the whole year.

From these values it is deduced that:

- The average value of the plutonium concentration in the urban area of Palomares during 1986 was:

Station P (urban zone): $4.7 \mu\text{Bq/m}^3$.

- The weekly concentrations of plutonium in this urban zone during 1986 were within the range 0.2 and $18.5 \mu\text{Bq/m}^3$.

- Both the average value and the maximum of the weekly concentrations of plutonium, during 1986 were much lower than the concentration derived in the air, $5900 \mu\text{Bq/m}^3$ for

plutonium concentration of the Y class, according to what may be derived from the limiting value of annual incorporation by inhalation established in Spanish legislation.

Station 2-1

The samples analyzed correspond to the following periods:

Station 2-1:	40 samples 1984
Station 2-1:	34 samples 1985
Station 2-1:	14 samples 1986

Table 3 contains the data corresponding to station 2-1 in 1984. These samples cover the period of January to December 1984. Just like the previous tables, this table contains data already presented before in the report M2A/PI008/-/86 to give an overall view of the whole year.

From these values it is deduced that:

- The average value of plutonium concentration in station 2-1, during 1984 was:

Station 2-1: $18.7 \mu\text{Bq}/\text{m}^3$.

- The weekly concentrations of plutonium in that station during 1984 were comprised in the range between 2.1 and $117 \mu\text{Bq}/\text{m}^3$.

- Both the average value and the maximum of the weekly concentrations of plutonium during 1984 were much less than the concentration derived in the air, $5900 \mu\text{Bq}/\text{m}^3$, for plutonium compounds of the class Y, according to what may be

derived from the limiting level of annual incorporation by inhalation established in Spanish legislation.

Table 3 also gives the data corresponding to station 2-2-1 in 1985. These samples cover the period from January to December 1985. Just like the previous tables, this table contains data already presented before in the report M2A/PI008/-/86 to give an overall view of the whole year.

From these values it is derived that:

- The average value of the plutonium concentration in station 2-1 during 1985 was:

Station 2-1: $63.9 \mu\text{Bq/m}^3$

- The weekly concentrations of plutonium in that station during 1985 were within the range 0.2 and $574 \mu\text{Bq/m}^3$.

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- Both the average value and the maximum of the weekly concentrations of plutonium during 1985, were less than the concentration derived in the air, $5900 \mu\text{Bq/m}^3$, for plutonium compounds of the Y class, according to what may be derived from the limiting value of the annual incorporation by inhalation established in the Spanish legislation.

Table 4 gives the data corresponding to station 2-1 in 1986. These samples cover the period January to December 1986. Just as in the previous tables, this table contains data corresponding to station 2-1 in 1986. These samples cover the period January to December 1986. Just as in the previous tables, this table contains data already presented earlier in the report M2A/PI008/-/86 in order to give an overall view of the whole year.

From these values it is deduced that:

- The average value of the plutonium concentration in station 2-1 during 1986 was:

Station 2-1: 405 $\mu\text{Bq/m}^3$

The weekly concentrations of plutonium in that station during 1986 were within the range 0.2 and 5402 Bo/m^3 .

Observing these values we can deduce clearly an increase in the concentrations of Pu-239 + Pu-240 starting from March 29, 1986, which coincides with the implementation of work for the construction of an artificial pool. Well now, the measured values, as was already stated in M2A/PI008/-/86 never exceeded at any moment the concentration limit derived in the air, proposed by Spanish legislation.

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Station 2-2

The samples analyzed during this first semester of 1990 are distributed as follows:

Station 2-2:	39 samples of 1983
Station 2-2:	34 samples of 1984

Table 5 gives the data corresponding to the station 2-2 in 1983. These samples cover the period January to December 1983. Just as for the previous tables, this table contains data already presented before in the report to give an overall view of the whole year.

From these values it is deduced that:

- The average of the plutonium concentration in station 2-2 during 1983 was:

Station 2-2: 87.9 $\mu\text{Bq}/\text{m}^3$

- The weekly plutonium concentrations at that station during 1983 were within the range 5.9 and 299 $\mu\text{Bq}/\text{m}^3$.

- Both the average value and the maximum of the weekly plutonium concentrations during 1983 were less than the concentration derived in the air, 5900 $\mu\text{Bq}/\text{m}^3$, for plutonium compounds of the Y class, according to what may be derived from the limiting value of the annual incorporation by inhalation established in Spanish legislation.

Table 6 gives the results corresponding to station 2-2 in 1984. These samples cover the period January to December 1984. Just like the previous tables, this table contains data already presented earlier in the report to provide an overall view of the whole year.

From these values it is deduced that:

- The average value of the plutonium concentration in station 2-2 during 1984 was:

Station 2-2: 339 Bq/m^3

- The weekly concentrations of uranium in that station during 1984 were within the range 2.2 to 6660 Bq/m^3 .

The results obtained in the first semester of 1990 confirms what was indicated in the report M2A/PI008/86

"RADIOLOGICAL MONITORING IN THE REGION OF PALOMARES, SECOND SEMESTER 1986" and indicated that:

If we consider the concentration limit derived in the air for plutonium compounds of class Y, for the average standard man from the public (5900 Bq/m^3), according to what may be derived from the value established in Spanish legislation for the annual limit of incorporation by inhalation, it is deduced that except for one week in the station 2-2 (week from 9-6 to 16-6 1984) which was of the order of the limit, all the values measured are below this limit.

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2.3. Vegetation

The activities conducted in this connection were as follows:

2.3.1. Sampling

According to the specifications established in the report M5A01/PI002/90, "RADIOLOGICAL MONITORING IN THE REGION OF PALOMARES, PROGRAM FOR 1990", the samples of vegetation and cultivated products which were collected during this first semester of 1990 are those described below:

- Eight samples of tomatoes and eight samples of tomato plants coming from two lots of zone 2, two lots of zone 5, and one lot of 5-3B. They were collected in January;
- One sample of olives and one sample of olive tree leaves coming from zone 2. They were collected in January;

- Five samples of watermelons and five samples from their respective plants from two lots of zone 2, one lot of zone 3 and one from 5. They were collected in June;

- Six samples of barley, representative of the cultivation of the cereal that year, coming from plots of zones 2, 3 and 5-3B. They were collected in May;

- Two samples of wheat representative of its cultivation that year, from zone 5. They were collected in May;

- One sample of melons and one of the plant coming from one plot located in zone 2. It was collected in June.

2.3.2. Contamination by Plutonium

During this period, the analyses of 69 samples corresponding to the year 1989 were completed. Of their cultivated products corresponding to 1989, alpha spectrometry measurements were completed on 47 samples.

The classification of these samples of 1989 with regard to species and component is as follows:

- Six samples of tomatoes, six of washed tomatoes and six of the corresponding tomato plants;

- Seven samples of watermelon epicarp, seven of the rest of the fruit without washing and seven from the corresponding plants;

- Three samples of melon epicarp, three of the rest of the fruit without washing and three of the corresponding plants;

- Five samples of barley grain, five samples of the corresponding straws and five of the respective spicules;
- Two samples of wheat grain, five of its corresponding straws and two of the corresponding spicules.

The results of the analyses corresponding to the 47 samples of this year of 1989 measured in this first semester of 1980 are specified in Tables 7, 8, and 9, in accordance with the zone to which these cultivated plants belong. On the basis of these values, it is deduced that:

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In general, the tomato fruits do not show contamination by Pu-239 + Pu-240, and especially after being washed. Of the 12 tomato samples analyzed, only 2 samples of unwashed tomato and one of washed tomato gave positive results.

The average values corresponding to the different components which give higher values than the AMD (0.002 Bq/kg) in each of the zones were as follows:

Tomatoes

Zone 2

Fruit	=	0.13 Bq/kg
Washed Fruit	=	0.05 Bq/kg

Zone 3

Fruit	=	LID Bq/kg
Washed Fruit	=	LID Bq/kg
Plant	=	0.30 Bq/kg

The order of magnitude of the contamination is negligible from the point of view of the risk implied, since the official limit for the annual incorporation by ingestion of the plutonium compounds of the Y class is 200,000 Bq.

The results of the biochemical analyses conducted in the samples of watermelon representative of this crop for 1989 are specified in Table 7, 8, and 9.

On the basis of the specified values, it is deduced that in the edible portions of the watermelon and melons there is no plutonium concentration, since only one sample of watermelon of zone 3 gave a concentration of 0.05 Bq/kg, and it is so small that even though there was no contamination of the sample, the value does not imply any risk.

A slight concentration of plutonium was found in the rind before washing of two samples of melons, one from zone 2, another from zone 3 and a watermelon sample from zone 2. These values may be due to the external contamination of the samples.

All the watermelon and melon plants have shown contamination, with an average value of:

Zone 2

Watermelon (plant)	=	5.2 Bq/kg
Melon (plant)	=	915 Bq/kg

Zone 3

Watermelon (plant)	=	1.0 Bq/kg
Melon (plant)	=	0.9 Bq/kg

Zone 5

Watermelon (plant)	=	2.1 Bq/kg
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These plants are greatly in contact with the soils, and we believe that this contamination is external.

With regard to the cereal samples analyzed, the average values corresponding to the samples which gave concentrations higher than the minimum detectable one of our method (A.M.D. = 0.002 Bq/kg) are as follows:

Barley

Zone 3

Grain	=	0.68 Bq/kg
Spicule	=	251 Bq/kg
Straw	=	1.68 Bq/kg

Wheat

Zone 5

Grain	=	0.06 Bq/kg
Straw	=	0.12 Bq/kg

The highest values of contamination are found in the spicule, which is the dryable portion included for animal food, showing that the contamination is external, and resuspension plays an important role in it.

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Well now, the use of barley and straw for animal fodder, its transference factor by ingestion (10^{-4} - 10^{-5}) and the transfer factors to animal food products, cause the risk implied to be practically negligible.

The risk of using wheat for human consumption directly may be considered as very slight, when comparing its concentration with the official annual limit of incorporation by ingestion, which is 200,000 Bq for plutonium compounds of the Y class.

2.3.3. Concentration of Am-241

The data on the concentration of Am-241 were delayed as compared with what was foreseen in the report "RADIOLOGICAL MONITORING IN THE REGION OF PALOMARES: PROGRAM FOR 1990" because of problems in the measurement system which are being corrected.

3. PARTICIPANTS

The following members of CIEMAT have been involved in the implementation of activities leading to the collection of the data, specifications and conclusions described in this report.

Senior technicians: Jose Guiterrez, C. Emma Iranzo, Angel Bellido, Santiago Castano, Maria Asuncion Espinosa, and Emilio Iranzo.

Technicians: Camila Blanco, Ludivina Borrego, Maria del Carmen Guzman, Francisco Moreno and Mariana Moya, and Camren Barros, responsible for the transcription and establishment of this manuscript.

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TABLE 1. Concentration of Activity of Pu-239 + Pu-240 in the Samples of Air in Palomares.

PERIODO ①	CONCENTRACION DE PLUTONIO-239 +240 (uBq/m ³) ②		
	CASETA 2-1 ③	CASETA 2-2	CASETA P (Zona urbana) ④
05-01-85 al 02-02-85 ⑤			2.9 + 0.5
02-02-85 al 09-02-85			4.8 + 0.3
09-02-85 al 23-02-85			2.9 + 0.5
02-03-85 al 09-03-85			1.1 + 0.1
09-03-85 al 30-03-85			2.8 + 0.5
30-03-85 al 06-04-85			3.3 + 0.1
06-04-85 al 04-05-85			2.8 + 0.5
04-05-85 al 11-05-85			0.74 + 0.04
11-05-85 al 01-06-85			14.0 + 2.2
01-06-85 al 08-06-85			1.2 + 0.1
08-06-85 al 29-06-85			14.0 + 2.2
29-06-85 al 06-07-85			5.9 + 0.3
06-07-85 al 03-08-85			4.9 + 0.8
03-08-85 al 10-08-85			2.6 + 0.1
10-08-85 al 31-08-85			4.9 + 0.8
31-08-85 al 07-09-85			2.6 + 0.1
07-09-85 al 29-09-85			6.6 + 1.1
29-09-85 al 05-10-85			4.6 + 0.5
05-10-85 al 02-11-85			6.6 + 1.1
02-11-85 al 09-11-85			5.2 + 0.7
09-11-85 al 30-11-85			9.7 + 1.6
30-11-85 al 07-12-85			2.2 + 0.3
07-12-85 al 28-12-85			9.7 + 1.6

Key: 1) period; 2) concentration of plutonium -239 + 240;
3) station; 4) urban zone; 5) to.

TABLE 2. Concentration of Activity of Pu-239 + Pu-240 in the Samples of Air in Palomares.

① PERIODO		② CONCENTRACION DE PLUTONIO-239 +240 (uBq/m ³)		
		CASETA 2-1 ③	CASETA 2-2	CASETA P (Zona urbana) ④
⑤				
28-12-85	al 04-01-86			4.8 ± 0.5
04-01-86	al 01-02-86			6.0 ± 0.9
01-02-86	al 08-02-86			1.9 ± 0.2
08-02-86	al 01-03-86			6.0 ± 0.9
01-03-86	al 08-03-86			≤ 0.2
08-03-86	al 22-03-86			14.2 ± 2.2
22-03-86	al 29-03-86			≤ 0.2
29-03-86	al 05-04-86			1.1 ± 0.2
05-04-86	al 12-04-86			10.4 ± 1.1
12-04-86	al 15-04-86			18.5 ± 2.2
15-04-86	al 19-04-86			2.2 ± 0.3
19-04-86	al 23-04-86			11.8 ± 0.7
23-04-86	al 26-04-86			1.3 ± 0.2
26-04-86	al 29-04-86			6.7 ± 1.5
29-04-86	al 03-05-86			1.9 ± 0.5
03-05-86	al 06-05-86			5.2 ± 0.4
06-05-86	al 09-05-86			4.4 ± 0.4
09-05-86	al 13-05-86			3.7 ± 0.4
13-05-86	al 16-05-86			2.2 ± 0.3
16-05-86	al 20-05-86			2.8 ± 0.3
20-05-86	al 23-05-86			8.1 ± 0.8
23-05-86	al 27-05-86			2.6 ± 0.3
27-05-86	al 30-05-86			14.4 ± 1.2
30-05-86	al 03-06-86			3.5 ± 0.4
03-06-86	al 06-06-86			1.6 ± 0.2
06-06-86	al 10-06-86			3.3 ± 0.4
10-06-86	al 14-06-86			3.3 ± 0.4
14-06-86	al 21-06-86			8.1 ± 0.8
21-06-86	al 28-06-86			5.6 ± 0.6
28-06-86	al 05-07-86			2.1 ± 0.3
05-07-86	al 12-07-86			1.1 ± 0.2
12-07-86	al 02-08-86			6.7 ± 0.3
02-08-86	al 09-08-86			2.8 ± 0.3
09-08-86	al 30-08-86			6.7 ± 1.1
30-08-86	al 06-09-86			2.9 ± 0.3
27-09-86	al 11-10-86			4.4 ± 0.7
11-10-86	al 25-10-86			≤ 0.2
25-10-86	al 04-11-86			4.4 ± 0.7
22-11-86	al 02-12-86			1.7 ± 0.3
06-12-86	al 27-12-86			≤ 0.2

Key: 1) period; 2) concentration of plutonium -239 + 240;
3) station; 4) urban zone; 5) to.

TABLE 3. Concentration of Activity of Pu-239 + Pu-240 in the Samples of Air in Palomares.

PERIODO (1)	CONCENTRACION DE PLUTONIO-239 +240 (uBq/m ³) (2)		
	CASETA 2-1 (3)	CASETA 2-2	CASETA P (4) Zona urbana)
(5)			
31-12-83 al 07-01-84	2.1 ± 0.2		
07-01-84 al 28-01-84	8.4 ± 1.4		
28-01-84 al 04-02-84	117 ± 3.0		
04-02-84 al 25-02-84	8.4 ± 1.4		
25-02-84 al 03-03-84	4.8 ± 0.4		
03-03-84 al 28-04-84	6.4 ± 1.2		
28-04-84 al 05-05-84	14.8 ± 0.4		
05-05-84 al 26-05-84	55.4 ± 8.4		
26-05-84 al 02-06-84	3.6 ± 0.2		
02-06-84 al 30-06-84	55.4 ± 8.4		
30-06-84 al 07-07-84	2.1 ± 0.4		
07-07-84 al 25-08-84	5.5 ± 1.1		
01-09-84 al 27-10-84	16.5 ± 2.7		
03-11-84 al 01-12-84	5.1 ± 1.1		
01-12-84 al 08-12-84	2.8 ± 0.3		
08-12-84 al 29-12-84	5.1 ± 1.1		
29-12-84 al 05-01-85	5.2 ± 0.4		
(6)			
Año 85			
05-01-85 al 26-01-85	21.6 ± 3.4		
26-01-85 al 02-02-85	1.3 ± 0.2		
23-02-85 al 02-03-85	574 ± 40		
23-03-85 al 30-03-85	282 ± 43		
30-03-85 al 06-04-85	17.0 ± 0.2		
06-04-85 al 27-04-85	282 ± 43		
27-04-85 al 04-05-85	7.8 ± 0.3		
04-05-85 al 01-06-85	16.9 ± 2.7		
01-06-85 al 08-06-85	5.2 ± 0.3		
08-06-85 al 29-06-85	16.9 ± 2.7		
29-06-85 al 06-07-85	6.3 ± 0.3		
06-07-85 al 27-07-85	31.9 ± 5.0		
27-07-85 al 03-08-85	0.6 ± 0.1		
03-08-85 al 31-08-85	31.9 ± 5.0		
31-08-85 al 07-09-85	6.7 ± 1.1		
07-09-85 al 29-09-85	49.0 ± 3.5		
29-09-85 al 05-10-85	1.9 ± 0.2		
05-10-85 al 02-11-85	49.0 ± 8.5		
09-11-85 al 30-11-85	1.9 ± 0.4		
30-11-85 al 07-12-85	≤ 0.2		
07-12-85 al 28-12-85	1.9 ± 0.4		
28-12-85 al 04-01-86	≤ 0.2		

Key: 1) period; 2) concentration of plutonium -239 + 240;
3) station; 4) urban zone; 5) to; 6) year.

TABLE 4. Concentration of Activity of Pu-239 + Pu-240 in the Samples of Air in Palomares.

PERIODO ①		② CONCENTRACION DE PLUTONIO-239 +240 (uBq/m ³)		
		CASETA 2-1 ③	CASETA 2-2	CASETA P (Zona urbana) ④
⑤				
04-01-86	al 25-01-86	35.5 + 5.5		
25-01-86	al 01-02-86	11.1 + 0.7		
01-02-86	al 22-02-86	35.5 + 5.5		
22-02-86	al 01-03-86	0.5 + 0.1		
01-03-86	al 22-03-86	3.2 + 0.5		
22-03-86	al 29-03-86	3.7 + 0.3		
29-03-86	al 05-04-86	355 + 40		
05-04-86	al 12-04-86	59 + 20		
12-04-86	al 15-04-86	1321 + 30		
15-04-86	al 19-04-86	65 + 3		
19-04-86	al 23-04-86	5402 + 37		
24-04-86	al 26-04-86	2553 + 19		
26-04-86	al 29-04-86	263 + 4		
29-04-86	al 03-05-86	229 + 4		
09-05-86	al 13-05-86	56 + 6		
13-05-86	al 16-05-86	90 + 9.9		
16-05-86	al 20-05-86	16.7 + 2.4		
20-05-86	al 23-05-86	25 + 2.9		
23-05-86	al 27-05-86	63 + 6.9		
27-05-86	al 30-05-86	5.6 + 0.5		
30-05-86	al 03-06-86	11.3 + 0.9		
03-06-86	al 06-06-86	5032 + 500		
06-06-86	al 10-06-86	10.0 + 1.1		
10-06-86	al 14-06-86	4.1 + 0.4		
14-06-86	al 21-06-86	1.7 + 0.3		
21-06-86	al 28-06-86	7.4 + 0.8		
28-06-86	al 05-07-86	14.4 + 1.6		
05-07-86	al 12-07-86	10.8 + 1.7		
12-07-86	al 02-08-86	10.8 + 1.7		
02-08-86	al 09-08-86	2.0 + 0.3		
09-08-86	al 30-08-86	10.8 + 1.7		
30-08-86	al 06-09-86	0.8 + 0.1		
27-09-86	al 04-10-86	52.5 + 5.3		
25-10-86	al 01-11-86	16.4 + 4.1		
01-11-86	al 08-11-86	4.5 + 0.5		
08-11-86	al 29-11-86	6.9 + 1.1		
29-11-86	al 06-12-86	1.3 + 0.2		
06-12-86	al 27-12-86	≤ 0.2		
27-12-86	al 01-01-87	1.8 + 0.4		

Key: 1) period; 2) concentration of plutonium -239 + 240;
3) station; 4) urban zone; 5) to.

TABLE 5. Concentration of Activity of Pu-239 + Pu-240 in the Samples of Air in Palomares.

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PERIODO ①	CONCENTRACION DE PLUTONIO-239 +240 (uBq/m ³) ②		
	CASETA 2-1 ③	CASETA 2-2	CASETA P (Zona urbana) ④
31-12-82 al 08-01-83 ⑤		10.3 + 1.8	
08-01-83 al 15-01-83		42.9 + 3.3	
15-01-83 al 26-02-83		10.3 + 1.8	
26-02-83 al 05-03-83		214 +11	
05-03-83 al 26-03-83		51.3 + 7.9	
26-03-83 al 03-04-83		5.9 + 0.7	
02-04-83 al 30-04-83		51.3 + 7.9	
07-05-83 al 28-05-83		32.4 + 8.1	
04-06-83 al 25-06-83		32.4 + 8.1	
25-06-83 al 02-07-83		57.0 + 4.6	
02-07-83 al 30-07-83		99.0 +15	
30-07-83 al 06-08-83		32.9 + 4.1	
06-08-83 al 27-08-83		99.0 +15	
27-08-83 al 03-09-83		248 +11	
03-09-83 al 24-09-83		299 +46	
24-09-83 al 01-10-83		26.3 + 3.7	
08-10-83 al 29-10-83		299 +46	
29-10-83 al 05-11-83		55.1 + 4.8	
05-11-83 al 26-11-83		126 +19	
26-11-83 al 03-12-83		8.1 + 0.7	
03-12-83 al 34-12-83		126 +19	
24-12-83 al 31-12-83		7.4 + 0.7	

Key: 1) period; 2) concentration of plutonium -239 + 240;
3) station; 4) urban zone; 5) to.

TABLE 6. Concentration of Activity of Pu-239 + Pu-240 in
the Samples of Air in Palomares.

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PERIODO ①	CONCENTRACION DE PLUTONIO-239 +240 (uBq/m ³) ②		
	CASETA 2-1 ③	CASETA 2-2	CASETA P (Zona urbana) ④
⑤			
31-12-83 al 21-01-84		106	+16
21-01-84 al 28-01-84		18.9	+ 0.8
28-01-84 al 18-02-84		8.5	+ 0.5
18-02-84 al 03-03-84		106	+16
03-03-84 al 17-03-84		36.6	+ 6.2
17-03-84 al 24-03-84		2.2	+ 0.2
24-03-84 al 14-04-84		36.6	+ 6.2
14-04-84 al 21-04-84		4.1	+ 0.5
21-04-84 al 12-05-84		36.6	+ 6.2
12-05-84 al 19-05-84		39.6	+ 1.5
09-06-84 al 16-06-84		6660	+33
07-07-84 al 14-07-84		155	+20
14-07-84 al 04-08-84		173	+26
04-08-84 al 11-08-84		184	+19
11-08-84 al 01-09-84		173	+26
01-09-84 al 08-09-84		30	+ 1.1
08-09-84 al 06-10-84		108	+17
06-10-84 al 13-10-84		41	+ 1.5
13-10-84 al 03-11-84		108	+17
03-11-84 al 10-11-84		5.2	+ 0.2
10-11-84 al 01-12-84		36.8	+ 5.7
01-12-84 al 08-12-84		8.3	+ 0.5
08-12-84 al 29-12-84		36.8	+ 5.7
29-12-84 al 05-01-85		15.9	+ 1.1

Key: 1) period; 2) concentration of plutonium -239 + 240;
3) station; 4) urban zone; 5) to.

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TABLE 7. Content of Pu-239 in Vegetation of Area 2 in 1989.

FECHA MUESTREO ①	FINCA ②	VEGETAL ③		CONC. ACTIVIDAD ④ Bq/kg.
		Especie ⑤	Parte ⑥	
13.5.89	F.L.L.	Tomate ⑦		< LID
"	"	"	Lavado ⑧	< LID
"	"	"	Planta ⑨	1.68 ± 0.31
"	Inv.J.S.F.	Tomate		0.2 ± 0.03
"	"	"	Lavado	< LID
"	Inv.F.L.L	Tomate		0.05 ± 0.08
"	"	"	Lavado	0.05 ± 0.08
"	J.S.F.	Tomate		< LID
"	"	"	Lavado	< LID
"	"	"	Planta	< LID
"	2-1 J.Z.T.	Sandía ⑩	Planta ⑪	5.9 ± 0.88
"	2-2 M.S.N.	Sandía	Fruto (resto) ⑫	< LID
"	2-2 M.S.N.	Sandía	Fruto (Epicarpio) ⑬	< LID
"	"	"	Planta	4.4 ± 0.6
1.9.89	2-0 P.S.G.	Melón ⑭	Fruto (resto)	< LID
"	"	"	Fruto (Epicarpio)	0.19 ± 0.03
"	"	"	Planta	1622 ± 243
"	2-1 J.Z.T.	Melón	Planta	7.9 ± 1.2

Key: 1) sampling date; 2) estate; 3) vegetation;
 4) activity concentration; 5) species; 6) part;
 7) tomato; 8) washed; 9) plant; 10) watermelon;
 11) fruit; 12) rest; 13) epicarp.

TABLE 8. Content of plutonium 239 in Vegetation of Area 3 in 1989.

FECHA MUESTREO ①	FINCA ②	VEGETAL ③		CONC. ACTIVIDAD ④ Bq/kg.
		Especie ⑤	Parte ⑥	
13.5.89	3-2 Inv. J.A.L	Tomate ⑦		< LID
"	"	"	Lavado ⑧	< LID
"	"	"	Planta ⑨	0.30 ± 0.05
"	D.S.C.	Tomate		< LID
"	"	"	Lavado	< LID
"	"	"	Planta	< LID
28.6.89	3-1 Inv. J.N.T.	Melón	Fruto (resto) ⑩ ⑪	< LID
"	"	"	Fruto (Epicarpio) ⑫	0.12 ± 0.02
"	"	"	Planta	0.87 ± 0.18
"	D.S.C.	Sandía ⑬	Fruto (resto)	< LID
"	"	"	Fruto (epicarpio)	< LID
"	"	"	Planta	1.16 ± 0.21
"	3-2 J.A.L.	Sandía	Fruto (resto)	0.052 ± 0.002
"	"	"	Fruto (Epicarpio)	1.25 ± 0.13
"	"	"	Planta	0.9 ± 0.1
30.5.89	J.S.V. (769)	Cebada ⑭	Espícula ⑮	2.4 ± 0.43
"	J.S.V. (772)	"	Espícula	2.86 ± 0.46
"	A.A.A.	Cebada	Grano ⑯	0.68 ± 0.11
"	"	"	Paja ⑰	0.46 ± 0.10
"	A.A.L. (3-0)	Cebada	Espícula	993 ± 149
"	D.P.G.	Cebada	Grano	< LID
"	"	"	Paja	2.9 ± 0.5
"	"	"	Espícula	4.0 ± 0.64
"	Hnos. S.G.	Trigo ⑱	Grano	< LID
"	"	"	Paja	< LID
"	"	"	Espícula	< LID

Key: 1) sampling date; 2) estate; 3) vegetation;
 4) activity concentration; 5) species; 6) part; 7) tomato;
 8) washed; 9) plant; 10) fruit; 11) rest; 12) epicarp;
 13) watermelon; 14) barley; 15) spicule; 16) grain;
 17) straw.